□ **A framework for assessing the welfare effects of EAS.**[17] Let x and z be two different exchanges containing N_x and N_z subscribers respectively. Consider the demand for telephone calls between two subscribers a and b that lie in x or z. Specifically, let the demand for calls from a to b be denoted by $y_{ab}(p)$.[18] We can denote the total demand for local calls within x and z by $y_{xx}(0) = \sum_{a=1}^{N_x} \sum_{\substack{b=1 \\ a \neq b}}^{N_x} y_{ab}(0)$ and $y_{zz}(0) = \sum_{a=1}^{N_z} \sum_{\substack{b=1 \\ a \neq b}}^{N_z} y_{ab}(0)$. Similarly, the total demand for long distance calls between x and z can be denoted by $y_{xz}(p) = \sum_{a=1}^{N_x} \sum_{b=1}^{N_z} y_{ab}(p)$ and $y_{zx}(p) = \sum_{a=1}^{N_z} \sum_{b=1}^{N_x} y_{ab}(p)$.

The question at issue is whether the introduction of EAS between exchanges x and z is justified on economic welfare grounds.[19] The welfare associated with the pre-EAS price structure is represented by

$$W_0 = \int_0^{\infty} [y_{xx}(\gamma) + y_{zz}(\gamma)]d\gamma + \int_{p_1}^{\infty} [y_{xz}(\gamma) + y_{zx}(\gamma)]d\gamma - (L_x N_x + L_z N_z)$$

$$+ p_1[y_{xz}(p_1) + y_{zx}(p_1)] + L_x N_x + L_z N_z - c_1[y_{xx}(0) + y_{zz}(0)]$$

$$- c_2[y_{xz}(p_1) + y_{zx}(p_1)], \quad (4)$$

where γ is the dummy of integration, L_x and L_z are the fixed monthly subscription charges, p_1 is the level of prices for long distance calls pre-EAS, and c_1 and c_2 are the long-run marginal costs of providing local and long distance telephone service, respectively.[20] The first and second integrals in (4) correspond to consumer surplus from local and long distance calls, respectively; the third term in (4), i.e., $L_x N_x + L_z N_z$, represents the reduction in consumer surplus due to the flat monthly charge; $p_1[y_{xz}(p_1) + y_{zx}(p_1)]$ represents pre-EAS long distance revenues; and finally, $c_1[y_{xx}(0) + y_{zz}(0)]$ and $c_2[y_{xz}(p_1) + y_{zx}(p_1)]$ are the costs associated with providing local and long distance service, respectively.

There are two types of EAS, namely one-way and two-way EAS. In the first case, subscribers in x (z) can call subscribers in z (x) at a zero marginal price, but if consumers in z (x) decide to call consumers in x (z) they will pay toll rates. In the second case, all subscribers, in both x and z, face a zero marginal price for all calls within the (enlarged) LCA.

The economic welfare under one-way EAS benefiting exchange x can be represented by

$$W_1 = \int_0^{\infty} [y_{xx}(\gamma) + y_{zz}(\gamma) + y_{xz}(\gamma)]d\gamma + \int_{p_1}^{\infty} y_{zx}(\gamma)d\gamma - (L'_x N_x + L'_z N_z)$$

$$+ p_1 y_{zx}(p_1) + (L'_x N_x + L'_z N_z) - c_1[y_{xx}(0) + y_{zz}(0) + y_{xz}(0)] - c_2 y_{zx}(p_1). \quad (5)$$

[17] Dansby (1980) provides the seminal treatment of spatial dimensions of utility pricing.

[18] For notational simplicity, all variables other than price (p) that influence demand are suppressed, and $CALLS_{xz}$ are henceforth denoted y_{xz} for all x and z.

[19] Following conventional methodology, the sum of consumer surplus plus producer surplus is taken as the measure of economic welfare. See, for example, Brown and Sibley (1986) and Griffin and Mayor (1987).

[20] Since long distance calls are billed on a per-call basis, a variety of costs associated with metering equipment is incurred. Since this additional capital investment is not necessary for local calls, $c_2 > c_1$.

Under two-way EAS, economic welfare can be denoted by

$$W_2 = \int_0^{p_0} [y_{11}(\gamma) + y_{22}(\gamma) + y_{12}(\gamma) + y_{21}(\gamma)]d\gamma - (L'_1 N_1 + L'_2 N_2)$$

$$- (L'_1 N_1 + L'_2 N_2) - c_1[y_{11}(0) + y_{22}(0)] - c_2[y_{12}(0) + y_{21}(0)]. \quad (6)$$

In both (5) and (6) the primes (′) indicate the possibility that the values observed under EAS pricing may differ from those in (4). Specifically, to the extent that the firm forgoes revenue on y_{12} in the case of one-way EAS and also on y_{21} in the case of two-way EAS, regulators may find it necessary to adjust L_1 and L_2 to satisfy the regulatory (and legal) constraint that profits be nonnegative. Equations (4), (5) and (6) combine to provide the change in economic welfare associated with the establishment of one-way and two-way EAS, given respectively by[21]

$$\Delta W_1 = \int_0^{p_0} y_{12}(\gamma)d\gamma - (p_0 - c_2)y_{12}(p_0) - c_2 y_{12}(0) \quad (7)$$

and

$$\Delta W_2 = \int_0^{p_0} [y_{12}(\gamma) + y_{21}(\gamma)]d\gamma - p_0[y_{12}(p_0) + y_{21}(p_0)]$$

$$+ c_2[y_{12}(p_0) + y_{21}(p_0)] - c_2[y_{12}(0) + y_{21}(0)]. \quad (8)$$

If ΔW_1 (ΔW_2) > 0, then the move to one-way (two-way) EAS is welfare enhancing and EAS pricing is preferred to current toll pricing. The signs of ΔW_1 and ΔW_2 will depend on (a) the increased consumer surplus arising from the price reduction on long distance calls, i.e., the two terms involving the integral signs in (7) and (8); (b) the loss in producer surplus due to the price reduction on long distance calls, i.e., $p_0 y_{12}(p_0)$ in (7) and $p_0[y_{12}(p_0) + y_{21}(p_0)]$ in (8); and (c) the change in operating costs associated with the transition to EAS, i.e., $c_2 y_{12}(p_0) - c_2 y_{12}(0)$ in (7) and

$$c_2[y_{12}(p_0) + y_{21}(p_0)] - c_2[y_{12}(0) + y_{21}(0)]$$

in (8).

Notice that when considering alternative tariffs to current toll pricing, regulators are not restricted to EAS pricing. In fact, an obvious (at least to economists) alternative is marginal cost pricing.[22] Instead of a zero marginal EAS price, the consumer will face a tariff that is equal to the marginal cost of providing the call. In this case, the welfare differential associated with the tariff change can be represented by

$$\Delta W_3 = \int_{c_2}^{p_0} [y_{12}(\gamma) + y_{21}(\gamma)]d\gamma - (p_0 - c_2)[y_{12}(p_0) - y_{12}(p_0)]. \quad (9)$$

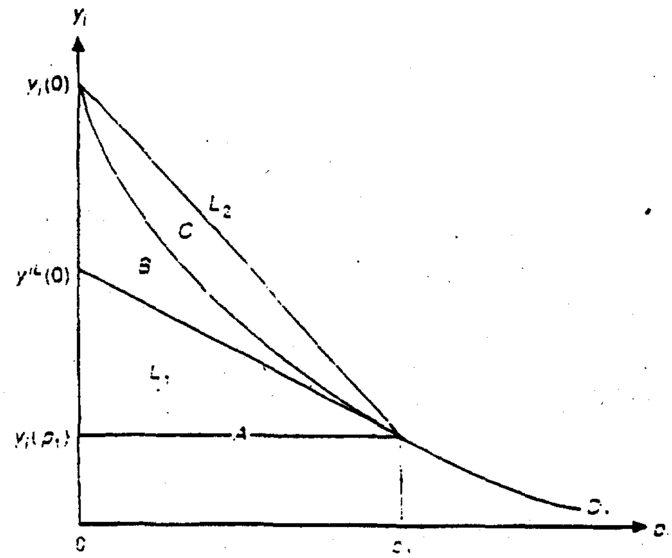
□ **The consumer-surplus impacts of EAS.** An important part of determining the economic merits of EAS revolves around the magnitude of the changes occurring in consumer surplus

[21] On the basis of prior empirical research on the demand for customer access to the telecommunications network, we assume that subscribership effects of implementing EAS are nil. See Taylor (1980), Perl (1983), and Kaserman, Mayo, and Flynn (1990). An extended discussion of subscribership effects in the context of EAS is contained in Martins-Filho (1992).

[22] In the presence of (particularly high) fixed costs, uniform marginal cost pricing may fail to generate revenues that allow the firm to cover its total costs. In this context, marginal cost pricing, which we consider here, together with a system of nondistortionary taxes remains the "first-best" pricing solution. Alternatives, not directly considered here, include "optimal" nonuniform prices and Ramsey prices. See Brown and Sibley (1986) for a discussion of these pricing alternatives.

FIGURE 1

UPPER AND LOWER BOUNDS OF THE WELFARE EFFECTS OF EAS FOR A REPRESENTATIVE EXCHANGE PAIR



when local calling areas are extended. Specifically, the larger the consumer-surplus benefits generated from the adoption of EAS, the more likely it is that the net economic welfare effects (i.e., including the change in producer surplus) will be positive. Accordingly, we now turn to a calculation of the changes in consumer surplus stemming from the implementation of EAS.

The nonlinearity of the demand dictates a careful analysis of the calculations involved in the welfare equations. Specifically, Figure 1 depicts a convex demand function for toll calls, where the number of calls (y_i) is represented on the vertical axis and a price variable (p_i) is depicted on the horizontal axis.[23] Our objective is to evaluate the integral

$$\int_{0}^{p_i} y_i(p)\,dp, \tag{10}$$

which provides a point estimate of the consumer-surplus gains brought about by the implementation of EAS. However, there are no observations on the level of prices for the interval $(0, p_i)$, where p_i is the pre-EAS level of prices. Hence, the shape of D_i in this interval is only suggested by the observed data. Since the curvature of D_i in this range is unknown, it is possible that a straightforward extrapolation of the estimated demand function could overstate or understate the consumer surplus gained by implementing EAS. It would therefore be desirable to provide upper and lower bounds on the estimated change in consumer surplus. Specifically, we construct a linear segment (L_2) from $y_i(0)$ to $(p_i, y_i(p_i))$. Because the demand function is assumed to be convex, it lies below L_2 for all $p \in (0, p_i)$. Thus, convexity of the demand function in the interval $(0, p_i)$ guarantees that the area $A + B + C$ is an upper bound (B_{ui}) on the consumer gains from EAS. Similarly, we construct L_1 by locating the slope of the tangency of the demand function at p_i and extending the segment to the ordinate axis. Again, by convexity, the demand function lies above L_1 for all $p \in (0, p_i)$. Thus, the area represented by A constitutes a lower bound (B_{li}) for the estimated value of EAS for exchange pair i.

Results of the demand estimation provide the specific basis to generate lower and upper bounds, as well as point estimates, of the consumer-surplus effects of EAS implementation.

[23] Recall that i represents an exchange pair as described in Section 2.

Specifically, the EGLS estimates of the previous section are used to locate the demand function for each pair of exchanges in P^2 space. For a representative pair i, we have

$$\hat{y}_i = \exp[\hat{\alpha}_i + \hat{\beta}_p p + .5\hat{V}_{\ln y_i}(p)], \tag{11}$$

where $\hat{y}_i$ is the estimated value for the number of calls for pair i, $\hat{\alpha}_i$ is the estimated intercept term for the demand function of pair i in P^2, which includes the effects of the nonprice variables by substituting the observed exchange specific values of these variables into the estimated demand function; $\hat{\beta}_p$ is the estimated parameter for the price variable; and $\hat{V}_{\ln y_i}(p)$ denotes the estimated variance of $\widehat{\ln y_i}(p)$ evaluated at p. (See, for example, Goldberger (1968) and Dadkhah (1984).) Given (11), we can represent the change in consumer surplus for the representative pair by

$$\int_{0}^{p_i} \hat{y}_i(p)\,dp, \tag{12}$$

which can easily be evaluated. The estimated gain in consumer surplus for all exchanges involved, i.e., the gains in consumer surplus generated by the implementation of two-way EAS, is given by

$$\Delta cs = \sum_{i=1}^{N} \int_{0}^{p_i} \hat{y}_i(p)\,dp. \tag{13}$$

While (13) provides a point estimate of the gains in consumer surplus resulting from the implementation of EAS, it is also possible to generate upper and lower bounds (B_u and B_l, respectively) on the point estimate. For pair i we can write

$$B_{ui} = 0.5 p_i \exp(\hat{\alpha}_i)[\exp(.5\hat{V}_{\ln y_i}(0)) - \exp(\hat{\beta}_p p_i - .5\hat{V}_{\ln y_i}(p_i))], \tag{14}$$

where p_i is the observed pre-EAS price level for exchange pair i. Hence, consumer gains with EAS implementation will be bounded above by

$$B_u = \sum_{i=1}^{N} B_{ui}. \tag{15}$$

To obtain B_l, first consider the equation

$$\hat{y}_i'(p_i) = \hat{\beta}_p \hat{y}_i(p_i), \tag{16}$$

which denotes the slope of the demand function for exchange pair i evaluated at pre-EAS price levels. We then project a linear demand function (denoted by y_i^L) with equal slope from the point $(p_i, \hat{y}_i(p_i))$ to $(0, y_i^L(0))$. We can then write

$$B_{li} = 0.5 p_i[y_i^L(0) - \exp(\hat{\alpha}_i + \hat{\beta}_p p_i + .5\hat{V}_{\ln y_i}(p_i))], \tag{17}$$

where $y_i^L(0)$ is the value of y_i^L at $p_i = 0$. Hence consumer gains with EAS implementation are bounded below by

$$B_l = \sum_{i=1}^{N} B_{li}. \tag{18}$$

Geometrically, (15) and (18) represent the summation over all exchange pairs of the areas A and $(A + B + C)$ in Figure 1, respectively.

Table 4 presents the annualized estimates of B_l, Δcs, and B_u for models 1, 2, and 3. The last three rows in Table 4—one-way EAS (*CORE*), one-way EAS (*NEW*), and marginal cost pricing—present the changes in consumer surplus associated with hypothetical price movements. In one-way EAS (*CORE*), we assume that one-way EAS was introduced

TABLE 4 Annualized Changes in Consumer Surplus Under Different Pricing Options (Million $)

Pricing Option	Demand Model (1)	(2)	(3)
Two-way EAS			
B_L	36.3	37.6	36.5
Point estimate	86.6	80.7	66.8
B_U	104.4	102.5	97.4
One-way EAS (*NEW*)	43.3	40.4	33.4
One-way EAS (*CORE*)	43.3	40.4	33.4
Marginal cost pricing	62.9	58.6	56.1

assisting only the *CORE* exchanges; therefore, for every i, if $x \in CORE$, consumers can call $z \in NEW$ at zero marginal price, but a call from z to x is a toll call. In one-way EAS (*NEW*), we assume that one-way EAS benefited $z \in NEW$ rather than $x \in CORE$. In these two cases, the change in consumer surplus for exchange pair i is given by (7), but for exchange pairs in which $x \in CORE$ ($z \in NEW$), the value of (7) will be zero under one-way EAS (*NEW*) (*CORE*). The aggregated change in consumer surplus in both cases is obtained by summing the estimated values of (7) over i. Finally, in marginal cost pricing we assume that prices moved from pre-EAS price levels to marginal cost levels.[24] Hence, the change in consumer surplus for exchange pair i is given by

$$\int_{p_i^{m}}^{p_i^{0}} \hat{x}_i(p)\,dp, \qquad (19)$$

which corresponds to the first term in equation (9). The sum of (19) over all i's provides aggregate estimates of the change in consumer surplus.

Clearly, the net economic welfare impact of EAS depends not only on changes in consumer surplus, but also on any changes in producer surplus that may arise from the implementation of EAS. As considered in the theoretical framework developed above, the change in producer surplus brought about by EAS originates from the revenue losses due to the price reduction of what were formerly toll calls and the change in operating cost brought about by the adoption of EAS. A detailed account of the methodology and data necessary to determine the changes in producer surplus associated with EAS is available upon request. Here we simply note that for the case of Tennessee, the annual producer-surplus losses associated with two-way EAS ranged from $44 to $46 million, depending on the particular model specification. Thus, the traditional measure of economic welfare, the summation of consumer surplus and producer surplus, is generally positive.[25] For the EAS plan adopted in Tennessee, the estimated net annual welfare gains (associated with our point estimates of consumer surplus) for two-way EAS varied from approximately $22 million in model 3 to $41 million in model 1.

6. Caveats and extensions

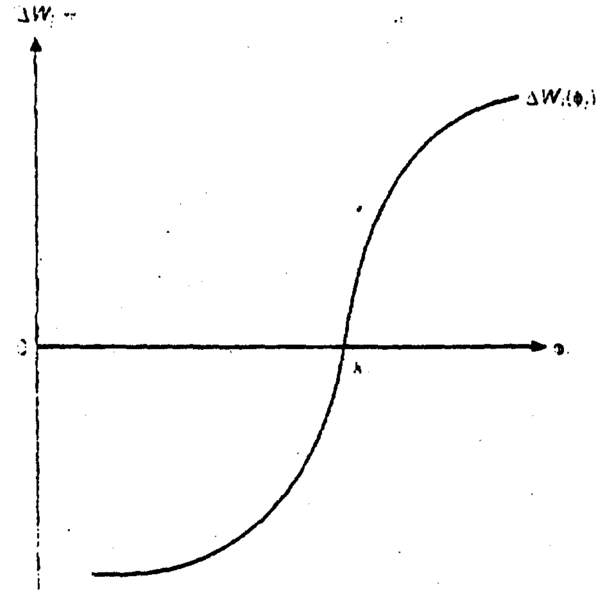
■ Although the welfare estimates associated with EAS implementation presented above are significant for both their existence and their magnitude, it is very important not to unduly extrapolate these results. For instance, the revealed increase in welfare due to im-

[24] The methodology to determine marginal cost levels is available upon request from the authors.

[25] The sole instance in which the net welfare change associated with EAS is negative occurs in the case of the lower bound estimates of consumer surplus.

FIGURE 2

THE RELATIONSHIP OF PRE-EAS PRICE-COST MARGINS AND THE WELFARE CHANGES FROM IMPLEMENTING EAS



plementation of EAS cannot be used as an outright basis upon which to recommend pricing telephone service at flat rates rather than measured service because in our case we do not compare an *optimal* pre-EAS tariff design to flat-rate pricing post-EAS. Indeed, extant studies that have assessed the economic welfare effects of measured service do exactly such a comparison (e.g., Griffin and Mayor (1987)), wherein the welfare associated with flat-rate local pricing is compared to the welfare levels generated by an alternative tariff designed to be welfare maximizing, given demand parameters and marginal cost characteristics. Therefore, while we find that flat-rate pricing under EAS tends to dominate existing toll tariffs, we cannot rule out the possibility (indeed, the likelihood) that there are pricing options that dominate the welfare generated by EAS.

Also, as is easily seen from equation (5), the larger the difference between pre-EAS toll prices and marginal cost, the larger will be the economic welfare gains from EAS pricing. Thus, when consumer surplus and producer surplus are summed, any positive welfare gain that may appear from EAS implementation is likely to be sensitive to some degree to the original distortions to economic welfare caused by toll prices with high-price marginal cost margins. Specifically, if we let price minus marginal cost for exchange i be φ_i, then the relationship between $\Delta W_i(\varphi_i)$ and φ_i can be seen in Figure 2.[26] Notice that there exists a $k_i > 0$ such that if $\varphi_i < k_i$ then $\Delta W_i(\varphi_i) < 0$. This indicates that at high pre-EAS toll rates, EAS will be welfare enhancing, while with lower toll price markups, implementing EAS will be welfare reducing.[27]

Finally, because our welfare estimates abstract from several other considerations that may affect the public-policy merits of embracing EAS, two additional caveats should be noted. First, given that the implementation of EAS enables local telephone companies to serve a possibly quite large share of the short-haul toll market at a zero price, EAS will preempt the possibility of competition for these calls. Specifically, even if regulators permit

[26] We have plotted this graph for models 1, 2, and 3. While the shape of $\Delta W_i(\varphi_i)$ is the same, the value of k_i varies with the specific model considered.

[27] This result was anticipated by Wenders (1987).

intraLATA competition from alternative long distance carriers, those carriers will be unable to compete with the prevailing zero marginal price.[28] Under these conditions the long-term effects of EAS pricing on welfare may be attenuated or reversed. Second, it is possible that EAS may have an effect on the availability and price levels of other services offered by the local telephone company. Specifically, the loss in revenues brought about by EAS pricing may well be large enough so that the $\pi \geq 0$ regulatory constraint is violated. In that case, the state public utilities commission will be forced to adopt a new rate structure in which other services provided by the local telephone company will be subject to rate increases, so that the regulatory constraint is once again met. These other services may or may not be confined to the exchanges affected by EAS; in fact, it has often been the case that the financial consequences of EAS plans have been distributed over the entire jurisdiction (state) of the public utilities commission.[29] Under this scenario, a pattern of cross-subsidization in which consumers in isolated exchanges (not benefiting from any type of EAS pricing) transfer resources to consumers in EAS areas. Although the use of cross-subsidization to attain specific socioeconomic goals has been an integral part of the history of telephony in the United States, such a pattern does not seem to fulfill any societal goal. Furthermore, to the extent that consumers outside the EAS area are affected by price increases, the overall welfare effect of EAS pricing becomes uncertain.

7. Conclusion

■ There are a number of unanswered economic questions about the observed geographic patterns of pricing telephone services. Prominent among them are the ones concerning the demand response and welfare consequences of extended area telephone service. In this article we have developed a demand model and framework to address these questions. Moreover, the recent implementation of an EAS plan in the metropolitan areas of Tennessee provided us with a unique opportunity to develop empirical estimates of the magnitude of the changes in both demand response and consumer surplus associated with EAS.

The empirical results indicate that demand is quite responsive to the implementation of EAS and that the consumer-surplus consequences of EAS are quite significant. But these results are shown to be sensitive to, among other things, the level of price-cost margins prevailing prior to the implementation of EAS.

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[28] Since the implementation of EAS enables local telephone companies to serve a substantial share of the intraLATA long distance market at zero price, EAS may play the role of a strategic action that preempts future competition in intraLATA markets. In fact, various states that allow intraLATA competition have instituted EAS pricing, therefore effectively eliminating competition on the exchanges affected by the plan.

[29] Examples of this widespread distribution of costs include the EAS plans introduced in Missouri (Kansas City and St. Louis) and Florida (various exchange pairs affected).

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